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COMBINING RELATIVE AND ABSOLUTE CALIBRATION METHODS TO ACHIEVE RADIOMETRIC CALIBRATION OF THE RAPIDEYE CONSTELLATION

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BlackBridge CalVal

CONTENT



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- Required temporal stability in the RapidEye constellation
- Temporal Calibration Approach
- Absolute Calibration Approach
- Combination of both methods
- Effect of the update

REQUIRED TEMPORAL STABILITY IN THE RAPIDEYE CONSTELLATION



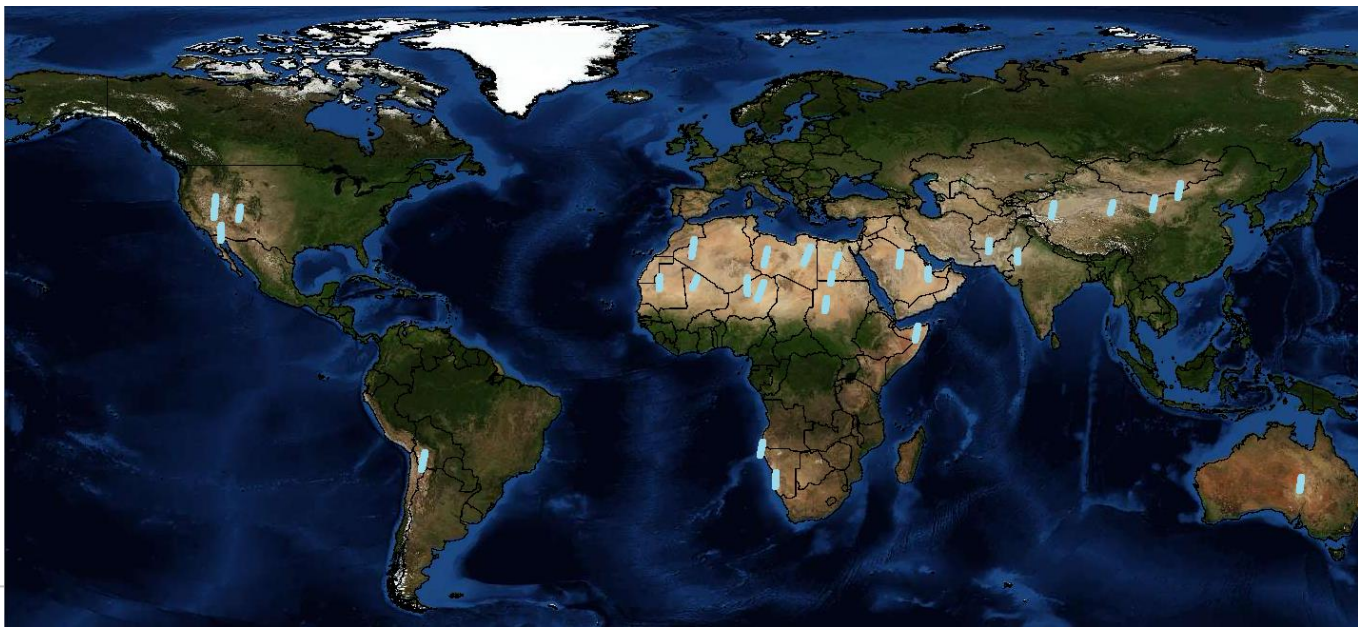
- RapidEye data is promised to be:
 - stable over time (less than 5% difference between two images no matter when they have been collected)
 - stable between the spacecraft (less than 5% difference between the same band of different satellites over the same target)
 - absolutely calibrated to radiance

RELATIVE TEMPORAL CALIBRATION



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- relative response between the bands on the individual spacecraft and over time are monitored steadily
- Statistical method based on bi-weekly images of 26 calibration sites



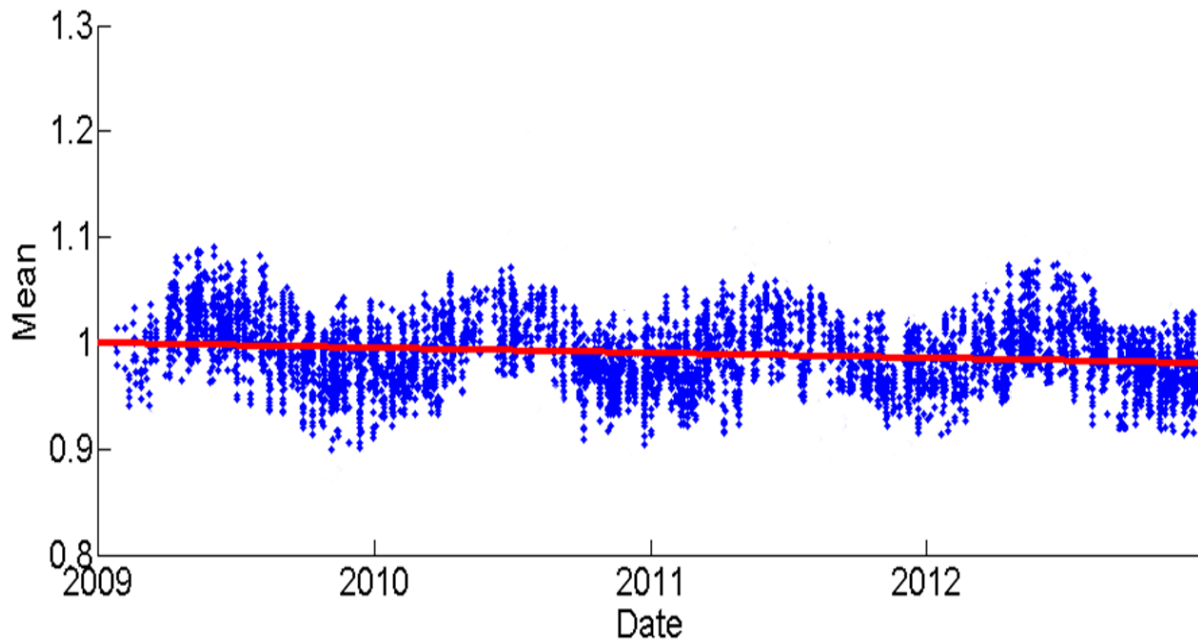
RELATIVE TEMPORAL CALIBRATION



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The normalized response of the combined 26 calibration sites over time (blue dots).

A per spacecraft and per band trendline shows the degradation of each sensor (red line).



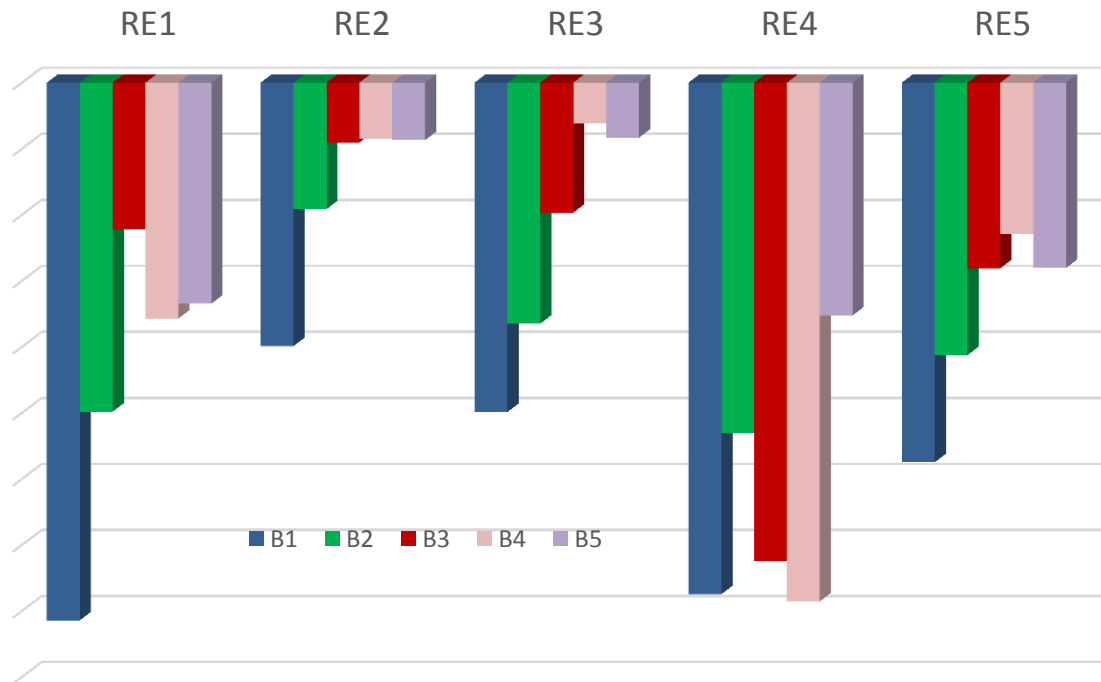
Example sensor response trend since the beginning of operations

RELATIVE TEMPORAL CALIBRATION



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Difference of raw sensor response between the beginning of operations (Jan. 01, 2009) and Dec 31, 2013



ABSOLUTE CALIBRATION



A number of absolute calibration campaigns have been executed between 2009 and 2013

- 2009/10 Ivanpah Playa and Railroad Valley Playa (2 SATs, 10 measurements)
- 2011 Railroad Valley (5 SATs, 5 measurements)
- 2012 Railroad Valley (5 SATs, 25 measurements)
- 2012 Brookings (5 SATs, 9 measurements)
- 2013 Railroad Valley (5 SATs, 5 measurements)

ABSOLUTE CALIBRATION



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Ivanpah Playa Calibration Site

Very bright and homogeneous

dry lakebed in the Mojave desert



ABSOLUTE CALIBRATION



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Railroad Valley Calibration Site

slightly darker than Ivanpah

dry lakebed



ABSOLUTE CALIBRATION



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Brookings Calibration Site

meadow site,
significantly darker
than the desert sites.



ABSOLUTE CALIBRATION



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Field equipment for absolute calibration:

- Sun Photometer
- Line-of-Sight Radiometer
- Wide Angle Photometer
- Field Spectrometer



FINDINGS FROM THE INDIVIDUAL METHODS



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- minor sensor degradations over the 5 years mission lifetime (expected and normal sensor behavior).
- field campaigns over the bright sites Railroad-Valley and Ivanpah-Playa meet the sensor response quite well (less than 3% off)
- field campaigns over the darker meadow site shows slightly larger deviation from the sensor measurements.

Why ?

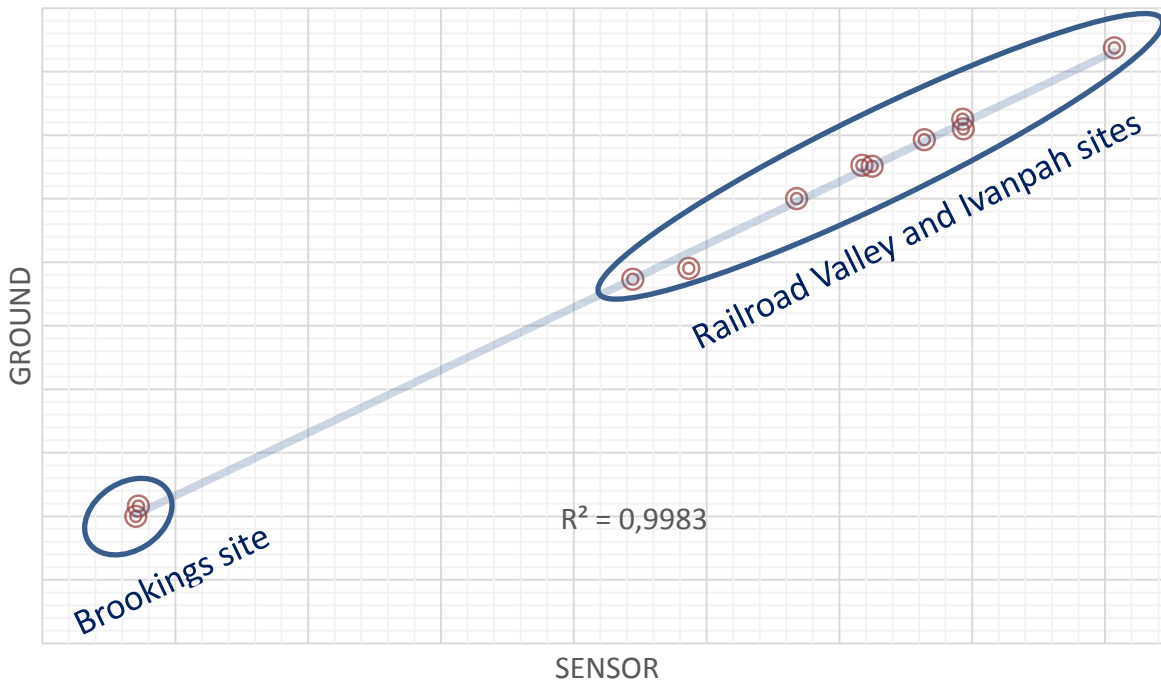
COMBINATION OF BOTH METHODS (ABS. CAL.)



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Correlation between different radiance levels from On-Ground and On-Board Measurements

=> On-Ground measurements seen as individual measurements form a close to perfect linear function



COMBINATION OF BOTH METHODS (ABS. CAL.)

- All previous calibration activities have been performed on similarly bright calibration sites
- Results matched the sensor response well
- Adding another darker calibration site showed slight disagreement with the original calibration settings
- Just changing the gain and offset from the abs-cal results would violate the 5% over time requirement
- To improve the accuracy for darker images the calibration needs to be updated for the full mission lifetime

COMBINATION OF BOTH METHODS (ABS. CAL.)



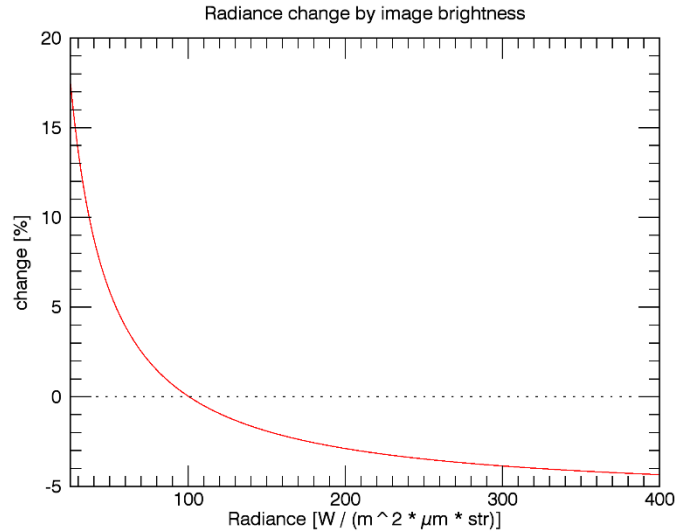
- Absolute calibration delivers very accurate results but they are snapshots over time
- Relative calibration delivers a very accurate trending of the sensor degradation over time but no a priori link to absolute radiance
- Using the linear fits from the absolute calibration and the relative temporal calibration allows creation of correction factors for all previous gain and offset tables and gives a very accurate absolute characterization for every point in time.

EFFECT OF UPDATE

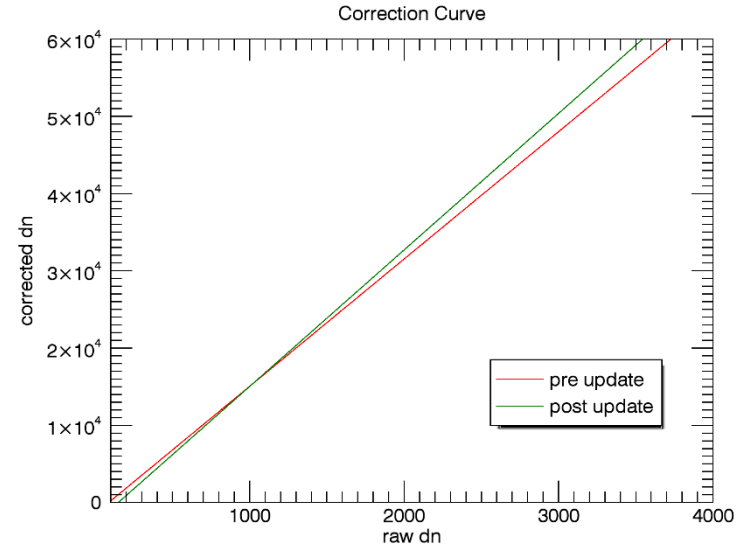


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- very dark surfaces change up to 15 %
- nearly no change on brighter surfaces



Example of the influence of the update
in relation to the image brightness



Correction curves used to convert raw DN's
into radiance

EFFECT OF UPDATE



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- The update has been made operational on Jan. 24, 2014 and covers all image product for the entire lifetime of the sensors.
- The update improves the absolute accuracy of the RapidEye radiance products.
- Changes and trends are different for each band of the constellation.
- Changes between old and new orders may be noticeable for very dark surfaces (forest, water, etc).
- Customers might want to take action if they work on multi-temporal datasets over dark surfaces.
- BlackBridge will provide support for customers affected by two different calibration settings of multi-temporal datasets.



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